Introduction

IT SETS HUMANS APART from all other species by allowing us to achieve the wonders of walking on the moon and composing masterpieces of literature, art, and music. The human brain — a spongy, three-pound mass of fatty tissue — has been compared to a telephone switchboard and a supercomputer.

But the brain is much more complicated than either of these devices, a fact scientists confirm almost daily, with each new discovery. The extent of the brain's capabilities is unknown, but it is the most complex living structure known in the universe.

This single organ controls body activities, ranging from heart rate and sexual function to emotion, learning, and memory. The brain is even thought to influence the immune system's response to disease and to determine, in part, how well people respond to medical treatments. Ultimately, it shapes our thoughts, hopes, dreams, and imaginations. In short, the brain is what makes us human.

Neuroscientists have the daunting task of deciphering the mystery of this most complex of all machines: how as many as 100 billion nerve cells are produced, grow, and organize themselves into effective, functionally active systems that ordinarily remain in working order throughout a person's lifetime.

The motivation of researchers is twofold: to understand human behavior better — from how we learn to why people have trouble getting along together — and to discover ways to prevent or cure many devastating brain disorders.

The more than 1,000 disorders of the brain and nervous system result in more hospitalizations than any other disease group, including heart disease and cancer. Neurological illnesses affect more than 50 million Americans annually, at costs exceeding $460 billion. In addition, mental disorders, excluding drug and alcohol problems, strike 44 million adults a year at a cost of some $148 billion.

Since the Decade of the Brain, which ended in 2000, neuroscience has made significant discoveries in these areas:

Genetics Disease genes have been identified that are key to several neurodegenerative disorders, including Alzheimer's disease, Huntington's disease, Parkinson's disease, and amyotrophic lateral sclerosis. These discoveries have provided new insight into underlying disease mechanisms and are beginning to suggest new treatments. With the mapping of the human genome, neuroscientists have been able to make more rapid progress in identifying genes that either contribute to or directly cause human neurological disease. Mapping animal genomes has aided the search for genes that regulate and control many complex behaviors.

Gene-Environment Interactions Most major diseases that have a genetic basis are strongly influenced by the environment. For example, identical twins have an increased risk compared with nonidentical siblings of getting the same disease; however, if one twin gets the disease, the probability that the other will also be affected is only 30 to 60 percent. Environmental influences include many factors such as toxic substances, diet, and level of physical activity but also encompass stressful life events.

Brain Plasticity The brain possesses the ability to modify neural connections to better cope with new circumstances. Scientists have begun to uncover the molecular basis of this process, called plasticity, revealing how learning and memory occur and how declines might be reversed. These discoveries are leading to new approaches to the treatment of chronic pain.

New Drugs Researchers have gained insight into the mechanisms of molecular neuropharmacology, which provides a new understanding of the mechanisms of addiction. These advances have led to new treatments for depression and obsessive-compulsive disorder.

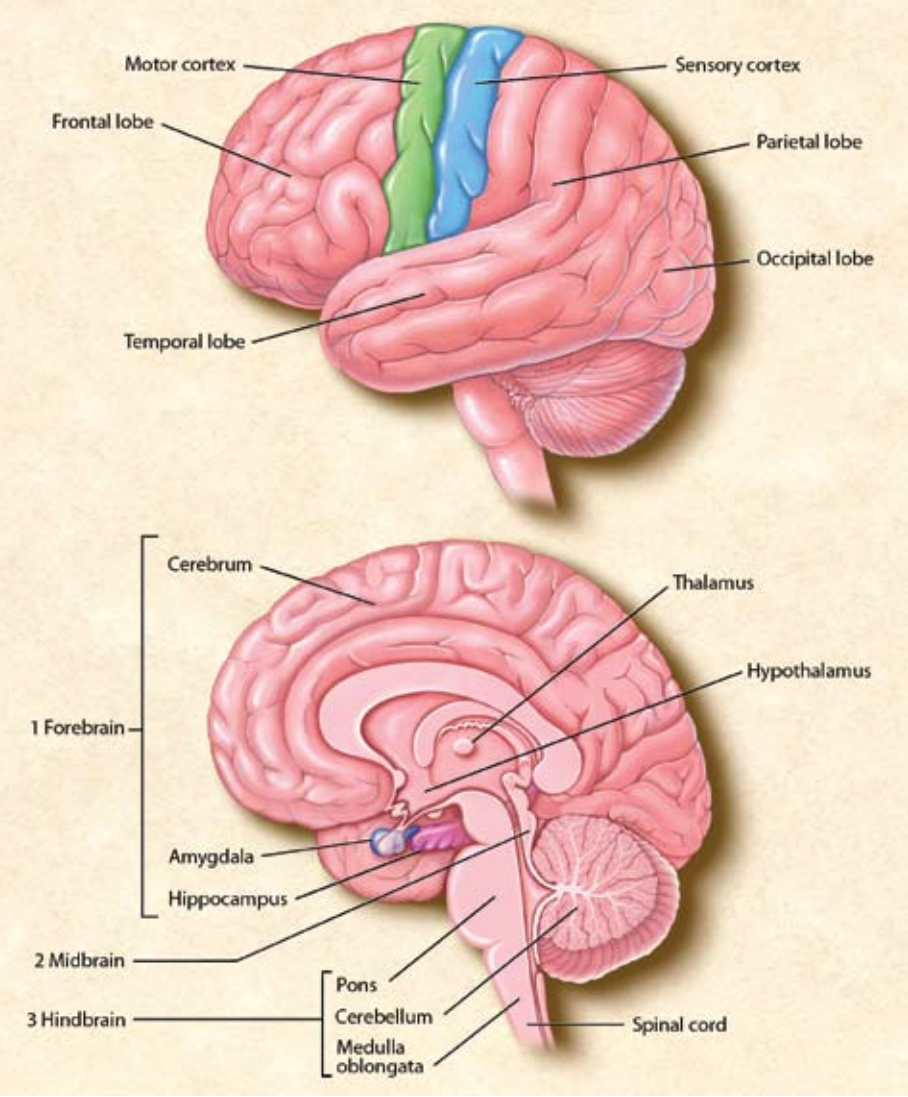
Imaging Revolutionary imaging techniques, including magnetic resonance imaging and positron emission tomography, have revealed the brain systems underlying attention, memory, and emotions and indicate dynamic changes that occur in schizophrenia and other disorders.

Cell Death The discovery of how and why neurons die, as well as the discovery of stem cells, which divide and form new neurons, has many clinical applications. This has dramatically improved the outlook for reversing the effects of injury in both the brain and the spinal cord. The first effective treatments for stroke and spinal cord injury based on these advances have been brought to clinical practice.

Brain Development New principles and newly discovered molecules responsible for guiding nervous system development now give scientists a better understanding of certain disorders of childhood. Together with the discovery of stem cells, these advances are pointing to novel strategies for helping the brain or spinal cord regain functions lost as a result of injury or developmental dysfunction.

Federal neuroscience research funding of more than $5 billion annually and private support will continue to expand our knowledge of the brain in the years ahead.

This book provides only a glimpse of what is known about the nervous system, the disorders of the brain, and some of the exciting avenues of research that promise new therapies for many neurological diseases.



THE BRAIN. Cerebral cortex (top image). This part of the brain is divided into four sections: the occipital lobe, the temporal lobe, the parietal lobe, and the frontal lobe. Functions, such as vision, hearing, and speech, are distributed in selected regions. Some regions are associated with more than one function. Major internal structures (bottom image). The (1) forebrain is credited with the highest intellectual functions — thinking, planning, and problem-solving. The hippocampus is involved in memory. The thalamus serves as a relay station for almost all the information coming into the brain. Neurons in the hypothalamus serve as relay stations for internal regulatory systems by monitoring information coming in from the autonomic nervous system and commanding the body through those nerves and the pituitary gland. On the upper surface of the (2) midbrain are two pairs of small hills, colliculi, collections of cells that relay specific sensory information from sense organs to the brain. The (3) hindbrain consists of the pons and medulla oblongata, which help control respiration and heart rhythms, and the cerebellum, which helps control movement as well as cognitive processes that require precise timing.

THE TOLL OF SELECTED BRAIN AND NERVOUS SYSTEM DISORDERS ON AMERICANS*

Condition	Total Cases	Cost per Year (U.S. dollars)
Sleep Disorders	70 million	100 billion
Hearing Loss	32 million	2.5 billion
All Depressive Disorders	20.9 million	70 billion
Traumatic Brain Injury	5.3 million	60 billion
Stroke	5.2 million	51 billion
Alzheimer's Disease	5 million	148 billion
Schizophrenia	2 million	32.5 billion
Parkinson's Disease	1 million	5.6 billion
Multiple Sclerosis	400,000	10.6 billion
Spinal Cord Injury	250,000	10 billion
Huntington's Disease	30,000	2 billion

** Estimates provided by the Centers for Disease Control and Prevention, National Institutes of Health, and voluntary organizations.*